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TABLE OF CONTENTS.

	PAGE
Original Articles:	
Solar Magnetism in Meteorology. Prof. FRANK H. BIGELOW	319
Variations in the Character of the Seasons. H. GAWTHROP	332
Current Notes:	
Recent Explorations of the Upper Air	340
Notes on the Hurricane of September 25–27, 1894	341
Annual Report of the Work of the Prussian Meteorological Institute	343
Annual Report of the New York Weather Service	343
Tornadoes in Iowa in September	344
The Roumanian Weather Service in 1893	345
Tornado Studies	345
Boletim da Commissão Geographica e Geologica do Estado de S. Paulo	345
Storm Tracks off the Eastern Coast of the United States	346
Correspondence:	
Newspapers and the Weather Bureau. H. M. WATTS	347
The Blackberry Winter. Mrs. M. L. STEPHENSON	349
Weather Maps and Forecasts in Sweden. Dr. R. RUBENSON	350
Observations on Cumulus Clouds at Winthrop, Mass. A. E. SWEETLAND	350
Bibliographical Notes:	
Destructive Effects of Winds on Sandy Soils	351
Distribution of Thunderstorms over the Earth's Surface	353
Effects of Weather Changes in Causing Disease	354
First Annual Report of the North Dakota Weather Service	355
Titles of Recent Publications	356

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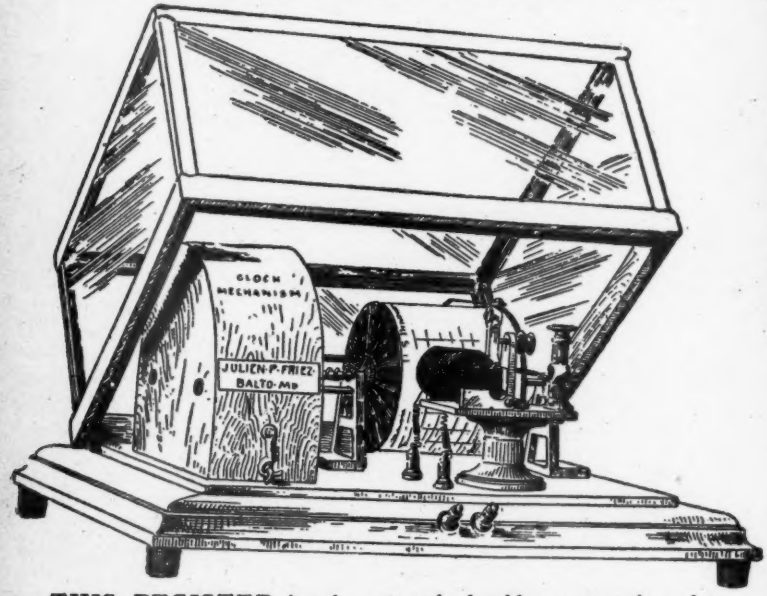

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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. XI. BOSTON, MASS., JANUARY, 1895. No. 9.

SOLAR MAGNETISM IN METEOROLOGY.*

PROF. FRANK H. BIGELOW.

IT is proposed to make in this article some general remarks on the present status of the group of associated problems arising out of the relations that have been already traced in my study of solar magnetism, and its influences upon meteorological phenomena. Brief abstracts of the results of an extensive computation may be found in "Astronomy and Astro-Physics," Nos. 118, 119, 121; THE AMERICAN METEOROLOGICAL JOURNAL, Sept. 1893; the "American Journal of Science," Dec., 1894. These remarks will be based upon the evidence therein set forth, while the practical experience gained in dealing with the material has gradually built up the aspect, or point of view, that I desire to describe.

1. *The primary problems.* A general inquiry into the processes of transmission of energy from the sun to the earth, in order to be comprehensive, must include all the modes that exist in nature. The ether through which the propagation takes place is a medium whose fundamental nature is by no means comprehended, but to it more important attributes are assigned as our knowledge of its properties extends. It has been for some years conceded that it sustains a system of electro-magnetic waves, generated at the sun, the energy of the same being propagated radially, or perpendicular to the wave fronts. These vibrations produce light effects; they are partially transformed into Joule's irreversible heat in the earth's atmosphere; a portion, as indicated by the theory, should be-

* Communicated by permission of the Chief of the Weather Bureau.

come static electricity, and it seems to me that this is the real source of the positive electric potential of the atmosphere; the component of magnetic induction has been shown by my computations to form a system of vectors capable of accounting fully for the diurnal and annual variations of the terrestrial magnetic field.

Now, the important question arises: Is this the only mode of propagation of energy from the sun to the earth? The existence of a series of phenomena, shown by observation to be interrelated to some extent, namely, the solar corona, the sun-spots, the zodiacal light, the aurora, terrestrial magnetic storms and earth currents, and a number of variations in the meteorological elements, naturally suggests that there is another method of transmitting solar energy to the earth. For these effects, whatever the cause may be, are clearly not the work of the electromagnetic field, their properties being inconsistent with its structure. A survey of the other possible modes of propagation easily indicates that polarized magnetic force, such a field of energy as surrounds a magnet, is the sole practical alternative. At first thought it seems a bold step to assume that spherical magnetic bodies the size of the sun can exist, filling all space with these peculiar curved rays, at least to the distance 93,000,000 miles, and yet the probability of this being the case seemed sufficiently great to justify the expenditure of the time and labor necessary to test it. If it can be demonstrated that such a polarized magnetic field exists, and that the above-mentioned group of phenomena are natural products of the same, then a rational basis will be secured for a true analysis of each of them.

2. *Steps in the proof of the existence of the solar polarized magnetic field.* This research encountered at the outset two serious obstacles: (1) the consensus of scientific opinion as to the improbability that the sun can be really magnetic at its high temperature; and (2) the difficulty of perceiving the right way to handle the enormous mass of observations available, and the risk involved in undertaking so much labor, lest the outcome be a disappointment. Regarding the first difficulty, it may be simply said that it is an assumption, and can be settled by an appeal to observation, which has now shown it to be incorrect. Also it should be remembered that heat or temperature is not

necessarily a measure and condition of the existence of energy. Ether energy is transformed into heat in the atmosphere of the earth, and yet the spaces between the earth and sun are vibrating with the same energy, though at zero temperature. As the coefficient of heat transformation depends upon the resistance of a medium to the transmission of energy, it is not difficult to admit that the forms of energy in the sun may not be incompatible with the existence of magnetic polarization. Indeed, on the molecular hypothesis of magnetization it is only necessary to assume that the axes of molecular circuitation are directed parallel to each other to have such a resultant exterior field of force.

As to the second difficulty, the opportunity to undertake and perform the work is due to the sagacity and generosity of Prof. M. W. Harrington, the Chief of the Weather Bureau. The leading points in the process of dealing with the observations and their bearing upon certain theories will be indicated in the following paragraphs. One general statement may be made as to the connection between the theory and the results of the computation of the observations. The principle has been strictly followed throughout the work, that the appeal should be primarily to the facts recorded, wholly uninfluenced by the theory. Therefore the data of the magnetic and the meteorological observatories have been marshalled and massed together, regardless of any hypothesis. Not an assumption derived from theory has been introduced from beginning to end, that in anywise compromises the results of the work. The theory might be wrong, and yet the results of the computations must be reckoned with in the future. All that has been done is to place the vast array of observations in such an order that they speak for themselves regarding their origin in nature.

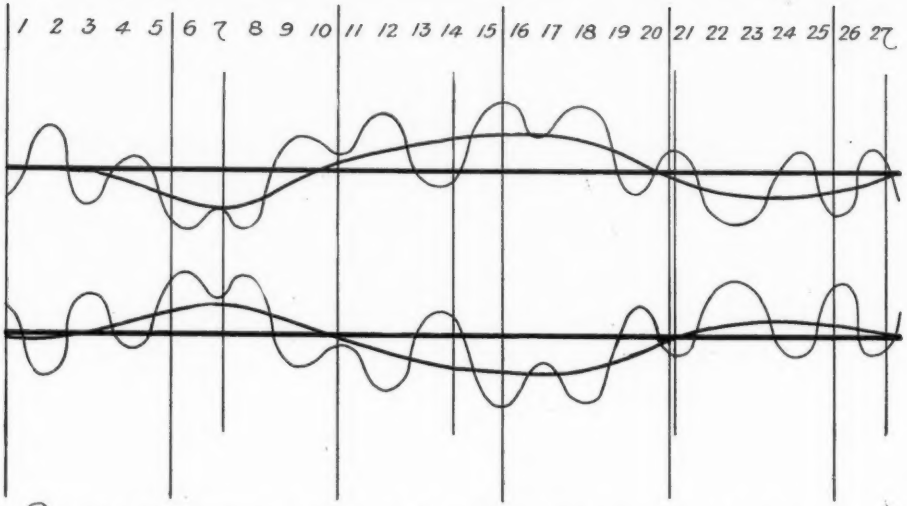
The progress of the investigation was made in three distinct stages: (1) The detection of the true period of the sun's rotation; (2) the determination of the intensity of the solar magnetic field from meridian to meridian of the sun; (3) the discovery of the inversion of the solar magnetism in certain periods.

The sun's synodic rotation in 26.68 days. The three rectangular components of the magnetic energy impressed upon the normal field were reduced to polar co-ordinates, by which their

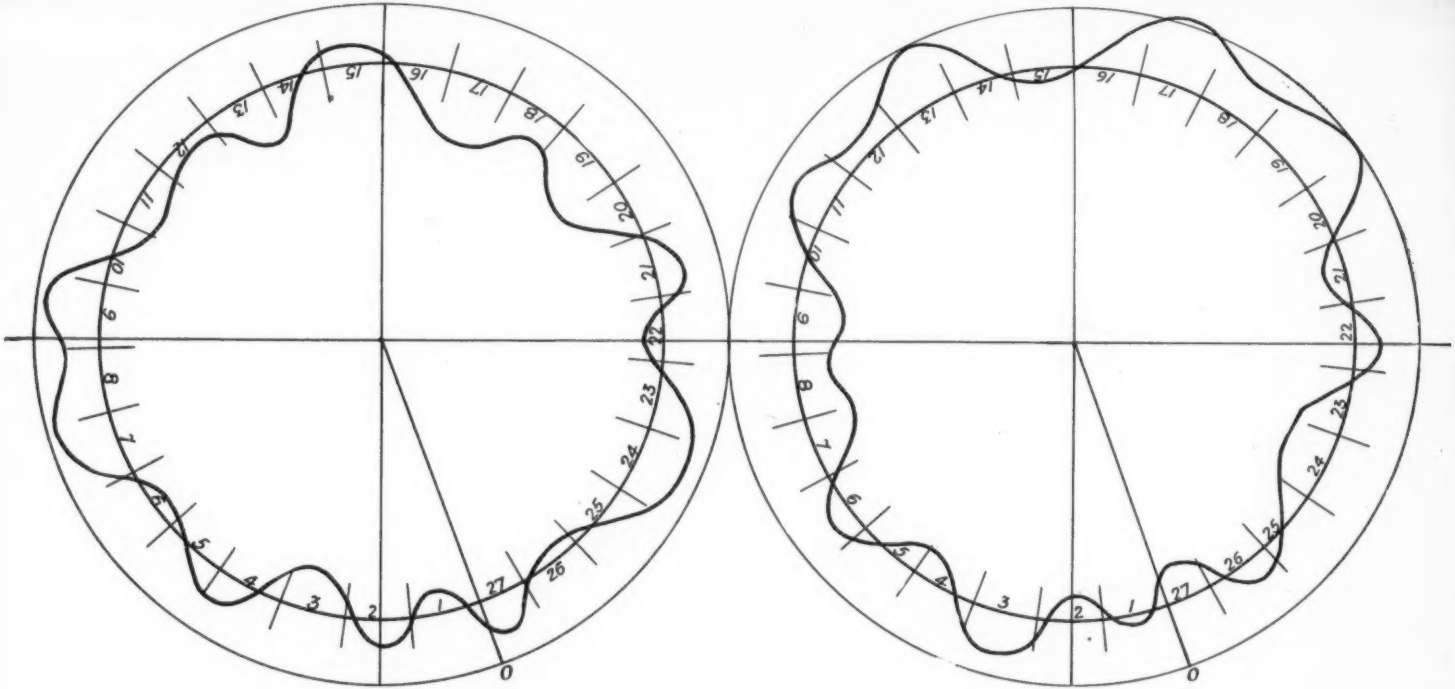
vector relations were fully seen, on the surface of the earth. These vectors showed a system of periodic changes, occurring in Europe and over the whole Northern Hemisphere simultaneously, so obvious as to make it easy to mark off the recurrences, simply by inspection. The observations of 1878–89 were thus treated year by year, resulting in the 26.68 day period. The general direction of the vector system was that of a polar field nearly perpendicular to the ecliptic. The success in developing the other parts of the problem has depended upon the accuracy of this period.

Now the fact that the earth's magnetic field does receive a definite impressed energy from the direction indicated, would seem to be positive evidence against the assumption that the sun does not act upon the earth by a direct magnetic field. All the theories that interpose the great distance of the sun or the existence of magnetic fields at solar temperatures, must therefore be revised. From computations on the solar coronas of the years 1878 and 1889, it has been shown that the visible curvatures of the rays are consistent with and are simply explained by identifying them with the magnetic lines of force surrounding a polarized sphere. Hence, we now have experimental evidence of these curved magnetic rays at the sun in the coronal polar rays, and at the earth in the vectors of the impressed magnetic field. It is difficult to avoid the inference that the entire space between the sun and the earth is filled with the lines of force of this polarized magnetic field.

This value of the solar period of rotation has an important bearing upon the theory of the constitution of the sun itself. The current ideas regarding the sun suppose that, on account of its low density, it is a vaporous body, with a system of convection currents between the interior and the surface. But it is evident that, if the sun sustains a periodic magnetic field throughout at least 225 revolutions, without irrecoverable variations, that the seat of the magnetic polarization must be in a nucleus of some kind, which is capable of undergoing slow periodic changes of its own, as indicated by the eleven-year sun-spot variations. Hence the photosphere must be a spherical shell of condensation at some distance from the surface of the nucleus, this system being also consistent with the observed density. The sun-spots are therefore phenomena of a thin shell,



Direct and Inverse types of the Magnetic Curves with the position of the Axes.



Direct.

Inverse.

Direct and Inverse types of the Variable Intensity of the Solar Magnetic Field in the 26.68 day Period.

the product of cooling convection currents, or of some system of circulation combined with change of physical state at the critical stage implied in the position of the visible surface. The mean daily motion of the sun-spots in longitude, following the lead of Carrington, has been taken usually as that of the body of the sun itself, 27.27 days, with an assumed acceleration of the equator due to unknown causes. It is, however, difficult to see any sound reason for supposing that the mean of the sun-spot movement is that of the sun itself, as in convection circulation the surface currents certainly differ from that of the body, except in certain well-defined zones. Now it happens that my mean daily motion, derived from the poles of the sun, 868′.758 minutes of arc, is nearly that of Carrington derived from sun-spots 867′.0, and also of the mean for Carrington, Spoerer, Faye and Tisserand, 867′.4. This agreement quite compels us to assume the equatorial rate as that of the nucleus itself, and upon it the solar phenomena, namely the spots, faculae, and prominences should be classified by typical meridians. It will be seen that it is this period which has successfully co-ordinated many of the terrestrial phenomena that have heretofore evaded classification.

The variation of the solar field in longitude, and the inversion of the system for different periods.

Although quite an interval elapsed between working out the variations of the solar field and the discovery of the fact of inversion, I will describe both together, in a general way. In order to facilitate this account, the following diagrams are introduced. The base line of the curve is 26.68 centimeters long, allowing one c. m. per day for the abscissas ; the ordinates represent the variable intensity of the impressed magnetic forces, due to the action of the solar field. The curve, therefore, indicates the relative distribution of magnetic masses in the nucleus of the sun from meridian to meridian, the ordinates showing an increase of intensity towards the centre. It must be remembered that this curve, or its approximate forms, has been obtained throughout 225 successive revolutions, and in my judgment terminates the old question of the direct solar magnetic action upon the earth in the affirmative. This normal type has been gradually approached by detailed study of the same in the magnetic and the meteorological elements, some of the minor fluctuations, as on the first, eighth, and nineteenth days

tending to obscure themselves on massing many periods together. The curve as it stands is readily seen to be *quite symmetrical about two axes at right angles to each other*, showing that we are not dealing with some fortuitous combination. It is indeed evident that we have the material for a solution in spherical harmonics of the distribution in the sun, at least to a first approximation, and that by a sufficiently extended study of this kind, we may expect to arrive at important knowledge regarding certain questions in solar physics.

Without a close value of the true solar rotation it would have been impossible to secure a curve so rapidly changing, since an imperfect period would soon fill the hollows with the crests. But even with this period it has been an exceedingly difficult curve to determine, for three reasons: (1) The sun is not a steady magnet, but as it is boiling, and changing its other components, so in this case the congestion and discharge involves a series of exaggerations or defections that distort the crests and hollows in such way as to produce a loose procession, so that the formations are not always prompt on the appointed day. (2) The earth's atmosphere is subjected to the action of two great fields of force, the equatorial and the polar, and between them the convection system of currents is produced. Hence it is evidently not easy to ascribe certain effects exclusively to the polar field; and the procession of crests and hollows suffers also from this complication with the convection due to the equatorial field. The nearest approach to purity of action of the polar field is to be found in the region of British America just north of Montana, near the place Long. 115° W., Lat. 55° N.; and setting out from this origin, I have found it a most fascinating study to watch the interplay of these two great systems, in the succession of Highs and Lows crossing the United States. But the irregular action of the sun, and the mixed convection of the earth's atmosphere are minor agents in the obscuring this typical curve. (3) It was found in following the northwestern temperatures from day to day that after a clear synchronism between the magnetic curve and the N. W. temperatures, a time came when it would be necessary to invert the magnetic curve on its axis in order to keep the march of Highs and Lows in the right sequence. The phenomenon is so marked that "he who runs may read," and yet it has done more to pre-

vent the discovery of the laws underlying the weather changes than all things else combined. For since the number of periods *direct* and *inverse* is about equal, the plus and minus residuals add up algebraically to nearly zero. After this fact was perceived, it was easy by plotting the individual temperature periods in the extreme northwest to identify the D and I types with considerable accuracy. Much work will yet be needed to fix the exact dates of inversion, but the result as it stands at present has been indicated in the paper mentioned in the American Journal of Science. It will be seen that the typical curve when plotted in the direct form is elongated about one axis, and in the inverse form about the other axis at right angles. This may point to the relative magnetic conditions of the North and South Hemispheres of the sun respectively, positive and negative magnetizations, but it is wiser not to speculate much while the nature of magnetic force in the ether is still the subject of investigation. At least we may perceive that generally on the north side of the ecliptic the ether is in one state of magnetic strain, while on the south side it is in the inverse type. The neutral surface of the sun may be an equipotential changing its position considerably in space as it follows the variable output of the sun from the poles ; or it may be that the movement of the earth in its orbit causes it to pass through a curved neutral sheet whose form is not known. It has also been shown that the sequence of the direct and inverse types among themselves has a singular relation to the sun-spot numbers in the eleven-year period.

The epoch for the ephemeris is 1887, June 12.22, but it will be seen that this zero is one day and a half too early for coincidence with the inverse axis, in the middle of the second day. The obvious advantage of adopting this one as the axis of reference induces me to *change the epoch to* 1887, *June* 13.72. The following ephemeris for five years, 1895–1899, is constructed on this basis. Also the preceding five years, 1890–1894, are made up on the old epoch, for studies in the last few years, if any are so disposed.

SOLAR MAGNETIC EPHEMERIS.

Period, 26.68 *Days.*

REFERRED TO THE EPOCH JUNE **12.22**, 1887.

1890.		1891.		1892.		1893.		1894.	
Jan.	1.02 I	Jan.	9.54 D	Jan.	18.06 D	Jan.	25.58 D	Jan.	7.42 I
Jan.	27.70 I	Feb.	5.22 I	Feb.	13.74 D	Feb.	21.26 D	Feb.	3.10 I
Feb.	23.38 D	Mar.	3.90 D	Mar.	11.42 D	Mar.	19.94 I	Mar.	1.78 I
Mar.	22.06 D	Mar.	30.58 I	April	7.10 D	April	15.62 I	Mar.	28.46 I
April	17.74 I	April	26.26 I	May	3.78 D	May	12.30 I	April	24.14 D
May	14.42 I	May	22.94 I	May	30.46 I	June	7.98 I	May	20.82 D
June	10.10 I	June	18.62 D	June	26.14 I	July	4.66 D	June	16.50 I
July	6.78 I	July	15.30 I	July	22.82 I	July	31.34 D	July	13.18 I
Aug.	2.46 D	Aug.	10.98 I	Aug.	18.50 I	Aug.	27.02 D	Aug.	8.86 I
Aug.	29.14 D	Sept.	6.66 I	Sept.	14.18 I	Sept.	22.70 D	Sept.	4.54 I
Sept.	24.82 D	Oct.	3.34 D	Oct.	10.86 I	Oct.	19.38 D	Oct.	1.22
Oct.	21.50 I	Oct.	30.02 I	Nov.	6.54 I	Nov.	15.06 D	Oct.	27.90
Nov.	17.18 I	Nov.	25.70 D	Dec.	3.22 I	Dec.	11.74 I	Nov.	23.58
Dec.	13.86 I	Dec.	22.38 D	Dec.	29.90 I			Dec.	20.26

REFERRED TO THE EPOCH JUNE **13.72**, 1887.

Adapted to the Rectangular Axes.

1895.		1896.		1897.		1898.		1899.	
Jan.	17.44	Jan.	25.96	Jan.	6.80	Jan.	15.32	Jan.	23.84
Feb.	13.12	Feb.	21.64	Feb.	2.48	Feb.	11.00	Feb.	19.42
March	11.80	March	19.32	March	1.16	March	9.68	March	18.20
April	7.48	April	15.00	March	27.84	April	5.36	April	13.88
May	4.16	May	11.68	April	23.52	May	2.04	May	10.56
May	30.84	June	7.36	May	20.20	May	28.72	June	6.24
June	26.52	July	4.04	June	15.88	June	24.40	July	2.92
July	23.20	July	30.72	July	12.56	July	21.08	July	29.60
Aug.	18.88	Aug.	26.40	Aug.	8.24	Aug.	16.76	Aug.	25.28
Sept.	14.56	Sept.	22.08	Sept.	3.92	Sept.	12.44	Sept.	20.96
Oct.	11.24	Oct.	18.76	Sept.	30.60	Oct.	9.12	Oct.	17.64
Nov.	6.92	Nov.	14.44	Oct.	27.28	Nov.	4.80	Nov.	13.32
Dec.	3.60	Dec.	11.12	Nov.	22.96	Dec.	1.48	Dec.	10.00
Dec.	30.28			Dec.	19.64	Dec.	28.16		

A couple of practical directions regarding the use of this ephemeris are here given. The first is, that it is so constructed to use with the twenty-four hourly observations, beginning with midnight of the civil day at Greenwich, that the *integral name of the day is to be retained*, even if the fraction is greater than 0.50, in massing a series of observations. The second is, that

the magnetic impulse acts simultaneously over the entire hemisphere, and the ephemeris can be applied directly in magnetic work for any longitude; while for meteorological work (this applies to the United States), the longitude from Greenwich to the origin, about eight hours, must be subtracted for the ephemeris hour of the magnetic impulse, and to that time must be added the interval elapsed for the convectional movement eastward to the station, say one day to the Dakotas, two days to the Mississippi Valley, and three days to the Atlantic coast, though this varies somewhat with the season of the year. Generally, the meteorological impulse of New England, the Middle and the Atlantic States is about two and a half days later than the ephemeris. Hence if the curves in these States are plotted as they occur from day to day, the magnetic curve must be slipped two and one-half days towards the right in order to fit synchronously. A short experience will show whether the type is direct or inverse. From September to June the curve can be easily traced, especially at the Dakota stations; in summer, the magnetic polar field is partially swallowed up in the heat of the atmosphere, due to the equatorial field; in summer, the flat condition of the convection currents, and in the winter the violent action of the same, tends to obscure the individual period curves; in the Southern States and the Eastern States, the true procession of the waves is more or less disintegrated by the interaction of the two fields. Yet in spite of all these perplexities, the meteorological problem has a rational line running through it from beginning to end, that will have a great influence upon its development. The typical curve is the best at hand, though it may be sometime improved. "Copy it on semi-transparent celluloid and match with the current temperatures, using at least *five* neighboring stations, allowing for the eastward drift from the northwest to your stations, and expect three or four inversions in the course of the year. All phenomena of the direct type must be discussed by themselves, and all the inverse by themselves, or in combination after the algebraic signs of the inverse have been changed to reduce them to the direct."

Some General Remarks.

1. I can only allude to the other argument for the direct connection between the solar magnetism and the terrestrial, magnetic, and meteorological elements, derived from the variation in the number of sun-spots, that of the European magnetic field, and the meteorological system of the United States, as shown in the curves for the years 1878 to 1893 inclusive. Here we have three systems of forces fluctuating synchronously for fifteen years, and in the case of the European and American fields in such a curve as to make it impossible to have occurred without the persistent action of a great impressed source of energy. Hence, we have now to deal with the facts that these three systems, the one at the sun, that of the magnetic field in the northern hemisphere, and that of the American meteorological field, vary together in block from year to year. It was also shown in a previous paper that the elements of the North Atlantic and of Europe shared in this systematic disturbance to some extent, my result being greatly obscured by the fact of inversion, then unsuspected. This harmony of pulsation also extends to the daily movements, to individual Highs and Lows, and to all the meteorological elements, the temperature, pressure, and precipitation. If the proof for the dependence of the state of the earth's atmosphere upon the polarized magnetic field of the sun, in part, at least, has been cumulative, the weight of testimony on the side of the question herein set forth is enormous, and by means of experience it has now reached those specific details which make a scientific theory valuable.

2. There is one general argument that appears to bear powerfully in the same direction. To many it may seem to be incredible that so intangible a type of energy as this polar magnetic field can produce such great effects. It may be recalled, as shown in the discussion of the globe model representing the magnetic vectors of the equatorial field from the sun, that we found therein an intensity of about the same magnitude. Yet the transformation of energy for this field is so great as to sustain many active forces on the Earth; and no doubt a transformation appropriate to the polar field builds up a system of effects comparable to that of the equatorial. Until we learn

what is the mode of the transmission of this live solar energy in the polar field, what it is that sustains these enormous curved magnetic lines of force many times 93,000,000 miles in length, along which is carried the energy that produces the magnetic storms, the auroral outbursts, and the earth currents, besides the power that whirls up the cyclones of the middle latitudes, we must withhold the statement that it is impossible. In my own opinion, after careful reading of the theories of electricity and magnetism, the electro-magnetic wave system is an incomplete description of such a live electric and magnetic body as the sun. We need, besides this, the magnetic circuits above described in these curved lines of force, and also a curved electric field on the equipotentials of the magnetic field. Of this there may be some evidence in the trumpet-shaped extensions of the solar corona. I am not sure but that we have here evidence of the existence of the hypothetical magnetic conduction currents, introduced by Heaviside to balance his duplex system of equations. But leaving these problems of the ether, and turning to strictly meteorological data, we have the following fact to consider. Besides accounting for the particular number in the procession of Highs and Lows crossing the United States per month, and the exact order in the sequence, consider the physical meaning of the inversion. This order, we will say the one designated *direct*, has been maintained through several periods, each magnetic crest and hollow being impressed upon the meteorological temperatures and pressures, albeit in a staggering fashion at times, from which proceeds the immense forces expended in the storms of the United States, with the combined action of the equatorial field and gravitation. Suddenly, within a day or two, this order inverts and the sequence in the procession is entirely different. It is a wonderful feat to have sustained the succession of storms in a given order; it is marvellous that this order can be instantly inverted and then sustained for several periods, to be reinverted again. As this peculiar action is easily traced through 225 solar revolutions, and continues in operation to-day for any one to inspect, it is a key to the combination we are trying to unlock.

3. I have already expressed my opinion that the convectional hypothesis of cyclones is untenable. The discontinuity in the mathematical treatment between the equations for the cyclones

and the anticyclones makes it very suspicious; the existence of the tropical hurricanes, with an insignificant increase of temperature at the centre; the fact that the extra-tropical cyclones show on the map a cold and a warm half, due to two encounter-sheets propelled from the Highs by the force of gravity; the existence of large rain areas without cyclonic circulation, and of cyclones fully developed without any precipitation, — all these discredit the hypothesis. In my judgment the primary masses are in the high areas, built up in the general circulation from the equatorial field, isolated, at least in North America, by the agency of the polar field. But however the Highs came into existence they form masses of potential energy under gravitation, and as they run down the encounter-sheets cause cyclonic gyrations with precipitation from lowering of temperature, both strictly as secondary phenomena. This reverses the order of the convectional hypothesis, which seeks to build up the Highs as products of the Lows, in spite of the fact that no adequate proof of the upward central warm convection current has been produced. It seems that the Highs are to be derived from the general circulation, as controlled over the hemisphere by the equatorial field, and locally in North America by the polar field, and that the cyclones, precipitation, etc., are strictly secondary effects in the disintegration of the Highs.

If this is not so, how can the following facts be explained? Since cool temperatures are more favorable for the action of magnetic forces, the winter months show a great increase in cyclonic forces over the summer, thus removing another difficulty raised by the convectional theory. The local origin of the Highs and Lows in the extreme northwest is explained by the presence in that neighborhood of the poles of magnetic concentration and of maximum cold. But if, as the convectional hypothesis assumes, the continental absorption and radiation is an important feature in the temperature centralizations upon which cyclones depend, how does it happen that the continent of North America differs so radically from that of Euro-Asia in the number of cyclones found therein respectively? On Chart 52 of Dunwoody's Summary of the Ten Years' Series International Observations, 1878–87, is given the storm frequency over the northern hemisphere; on Chart 53, the storm tracks. Making due allowance for the lack of observations in Siberia, it is

evident that the maximum of cyclonic action is in the United States, and the minimum in Siberia. The latter is characterized by a great, permanent, unbroken High in winter, and a vast, quiet Low in summer; the former by a rapid succession of small Highs and Lows in winter, forming storms that run eastward to break up on the European face of the continent, and in summer by a similar feeble pulsating in the extreme northwest, which soon fades away in the progress eastward. Thus for ten years **480** storms passed the upper St. Lawrence Valley, and in Siberia less than **40.** I explain this great difference by the intermittent action of the energy impressed by the crests and hollows of the polar field breaking up into detached masses the High and Low areas, the sequence being that due to the energy put forth on certain meridians of the sun. If the action is merely continental, it is practically impossible to assign features to one continent not common to the other which can reasonably cause this wide differentiation of effects, as indicated by the succession of cyclones in a special order. The external impressed solar magnetic field harmonizes the discrepancy very simply.

4. It is easily seen that the consequence of the discovery of the existence of the polarized solar field is to open up a series of interesting physical problems. Such are the distribution of solar magnetism, a problem in spherical harmonics; the conduction of magnetic radiation through the ether, a problem on the related properties of electricity and magnetism; the curvature and constants of the lines of magnetic force in entering the earth, a problem in lines of force; the transformation of magnetic energy in the atmosphere, involving a solution of the auroral phenomena, the magnetic storms and earth currents, and the irreversible heat of the polar regions; the reconstruction of the mathematical theory of the cyclonic circulation; the application of the results of these researches to the practical art of long range forecasting, as well as that of interpreting the daily weather maps for the 24-hour and the 36-hour forecasts.

Progress has already been made in several of these problems, by reducing the available observations, and in considering the various mathematical relations involved. The difficulty and range of these questions is so great that we must feel contented if even slow advances can be made. Aside from such obstruc-

tions, the chief obstacle to advancement consists in the total lack of magnetic observations in the extreme Northwest. The transfer of the admirable European observations to that field of operation is so indirect as to make it unsatisfactory to rely upon such data. Aside from the series of the International Observations of 1882–1883, there is little to depend upon. Hence it seems plain that one of the pressing demands of science is to plant at least five permanent magnetic observatories near the northwest border of the United States, say at Sitka, Edmonton, Fort Buford, Duluth, Sault Ste Marie, or equivalent positions, which with Toronto, Washington, and San Antonio would give us, in a few years, the material to pass from approximate to definite solutions of the physical constants involved.

VARIATIONS IN THE CHARACTER OF THE SEASONS.

H. GAWTHROP.

THE division of the year into four seasons is the traditional order venerated by astronomical usage and consecrated by the poets, but when measured as phases of weather it is not possible to fix these periods within definite limits, either as to time or character. Instead there are protracted spells of weather which seem to defy all the normal seasonal conditions. This is particularly manifest to popular observation in the persistently cold or warm winters, and in the long periods of drought or excessive rainfall. It is important that these prolonged departures from the normal of the seasons shall be measured, if the cause which we know not we are to search out.

In the February, 1894, number of this JOURNAL I presented a plan for measuring the courses of temperature by averaging the daily means progressively in thirty-day periods. To confirm and illustrate the method thus proposed, a close parallel is found in the waves and tides of the ocean. Suppose that for each wave we had several measurements, by a tide gauge, giving the distance of the surface of the water above or below sea level, and that taking a sufficient number of these measurements along a straight line to span several waves, we should average them, the result would be a mean approximating closely the distance from the surface of the water to the sea level. Then

if we should drop a measure at one end of our line and taking up another at the other end, averaging again for a second mean, and thus proceeding progressively, we would establish a line of means, practically giving the state of the tide. The process has eliminated the waves, and if continued the line would in time cross the normal, or sea level, indicating a change in the tide. The surface of the ocean is affected by two conditions in combination: the undulations of the waves, and the larger movements of the tides. By this progressive average, the one has been reduced to obtain the other.

The mercury in the three thousand and more officially recognized thermometers distributed over this country is not less concrete than the water alongside of the tide-gauges, and in measuring its fluctuations there is no more need for this calculation to take temperature into consideration than gravitation in thus determining the tides.

The duration and range of temperature courses for a period of five years at the Philadelphia station of the Weather Bureau, made up from thirty-day progressive means, are shown in the table below.

Each course is counted from the extreme departure on one side of the normal to the extreme on the other side, the movement from one to the other being remarkably steady. The largest cyclonic waves, however, are not altogether eliminated, so that in long courses of slight departure, when the normal is crossed for a few days, and it is manifestly not a change in the general condition, a change of course is not counted. However, in a table of departures at five days' interval, there are but two such exceptions for the five years. During the whole period there were 44 courses, averaging 42½ days each, with an average range of 7°, the longest being a course from Oct. 3, 1889 to Jan. 2, 1890, when there was a change of 18.5° from minimum to maximum.

It may be of significance in considering causes to note that during a year there appear about four temperature seasons warmer, and four colder than the normal, the maxima or minima occurring in ten different months in five years. The popular conjecture as to what kind of a summer will follow a particular winter or the reverse will not find much to build upon in the table, and, considering the irregularity of the periods, it would

TEMPERATURE COURSES, PHILADELPHIA, PA.

	Minimum to Maximum.						Maximum to Minimum.					
	From	Below °	To	Above °	No. of Days	Range °		From	Above °	To	Below °	No. of Days.	Range °
	1888		1888					1888		1888			
1	Oct. 9	7.8	Nov. 7	2.9	29	10.7	1	Nov. 7	2.9	Dec. 1	1.9	24	4.8
			1889					1889		1889			
2	Dec. 1	1.9	Jan. 14	8.0	45	9.9	2	Jan. 14	8.0	Feb. 18	3.6	35	11 6
							3	May 4	6.6	June 5	1.8	32	8.4
	1889						4	Sept. 3	1.9	Oct. 8	4.5	30	6.4
3	Feb. 18	3.6	May 4	6.6	75	10.2		1890		1890			
4	June 5	1.8	Sept. 3	1.9	90	3.7	5	Jan. 2	14.0	July 12	2 3	191	16.3
			1890				6	Aug. 8	1.6	Aug. 21	1.3	13	2.9
5	Oct. 8	4.5	Jan. 2	14.0	91	18.5	7	Sept. 9	1.7	Oct. 21	1.8	42	3.5
							8	Nov. 17	3.4	Dec. 17	2.4	30	5.8
	1890							1891		1891			
6	July 12	2.3	Aug. 8	1.6	27	3.9	9	Feb. 4	6.4	March 29	2.5	53	8.9
7	Aug. 21	1.3	Sept. 9	1.7	19	3.0	10	April 27	5 8	May 27	2 1	30	7.9
8	Oct. 21	1.8	Nov. 17	3.4	27	5.2	11	June 15	0.5	July 17	4.2	32	4.7
			1891				12	Sept. 27	5.7	Oct. 24	5.1	27	10.8
9	Dec. 17	2.4	Feb. 4	6.4	49	8.8				1892			
	1891						13	Dec. 19	6 8	Feb. 4	1.9	47	8.7
10	March 20	2.5	April 27	5.8	29	8.3		1892					
11	May 27	2.1	June 15	0.5	19	2.6	14	Feb. 13	0.8	March 9	4.1	25	4.9
12	July 17	4.2	Sept. 27	5.7	72	9.9	15	April 6	2.1	April 25	2.2	19	4.3
13	Oct. 24	5.1	Dec. 19	6.8	56	11.9	16	June 13	3.1	July 9	1.9	26	5.0
							17	Aug. 7	3.9	Sept. 7	1.5	31	5.4
	1892		1892										
14	Feb. 4	1.9	Feb. 13	0.8	9	2.7				1893			
15	March 9	4.1	April 6	2.1	28	6.2	18	Oct. 8	1.8	Jan. 7	12.7	91	14.5
16	April 25	2.2	June 13	3.1	49	5.3							
17	July 9	1.9	Aug. 7	3.9	29	5.8		1893					
18	Sept. 7	1.5	Oct. 8	1.8	31	3.3	19	March 26	2.8	April 25	3.4	30	6.2
							20	June 7	2.2	July 10	1.9	33	4.1
	1893		1893				21	Aug. 15	2.3	Sept. 17	1.8	33	4.1
19	Jan. 7	12.7	March 26	2.8	78	15.5	22	Oct. 20	1.5	Nov. 13	3.5	24	5.0
20	April 25	3.4	June 7	2.2	43	5.6							
21	July 10	1.9	Aug. 15	2.3	36	4.2							
22	Sept. 17	1 8	Oct. 20	1.5	33	3.3							
			Average for 22 Courses		44	7 2				Average for 22 Courses		41	7.0

seem useless to sum up an entire year's temperature to compare with that of another year, or even to count by calendar months as to effect upon crops.

The more persistent the course and the wider the departure the greater is the extent of the movement. In order to show the vast territory covered by the extreme departures and to compare with Philadelphia, I have selected stations in a line across the track of the cyclones from Alpena on the Upper Lakes to Galveston on the Gulf. Then from data for the phenomenally warm winter of 1889–90, I have calculated, by progressive means, the courses of temperature at each station, with the following result : —

Stations.	First Crossing of Normal.	Highest Departure.	Return across Normal.
Philadelphia.....	Oct. 30, 1889.	Jan. 2, 1890, 14.0°.	Mar. 17, 1890.
Alpena	Nov. 6, 1889.	Dec. 22, 1889, 10.4°.	Feb. 22, 1890.
Indianapolis.....	Nov. 21, 1889.	Dec. 29, 1889, 16.6°.	Feb. 20, 1890.
Memphis.....	Nov. 22, 1889.	Dec. 29, 1889, 21.1°.	Feb. 21, 1890.
Galveston.	Nov. 23, 1889.	Dec. 29, 1889, 14.3°.	Feb. 28, 1890.

On the Pacific coast during the same period almost the opposite conditions were experienced, the temperature movement being below the normal.

If deductions, in the same manner, should be made from the records of all the regular stations of the United States Weather Bureau, the result would show the length, breadth, height, depth, beginning, duration, and ending of these vast temperature "areas" within the limits of this country.

In the popular treatment of the subject of meteorology the emphasis has been placed, in recent years, upon the cyclonic storms and the necessity of forecasting them, as affecting so closely the daily life, but it may be that the general movements are of more importance to generations of people, in the demands upon their endurance and in the promotion of their happiness.

When the temperature tide, as represented by the progressive means, falls below the normal in the summer months, the exodus to mountain and shore falls off, but if the line rises above the normal then are the hearts of the proprietors of summer resorts made glad. The death rate of the cities increases with the persistence of high temperature in summer, and, to judge by the appearance of the grip in the winter of 1889–1890, sickness is increased by abnormally high temperatures in winter as well as by extreme cold in that season.

The manufacturer and merchant prepare clothing of wool, fur, and rubber for the expected cold winter, and a mild, open winter following instead, stocks of goods are carried over at great loss and mills stand idle; while a second open winter in succession brings disaster to many industries. The character of the winter also affects the ice crop, and the kind of summer following has much to do with marketing it.

In the most important of all industries, agriculture, the effect of these variations in the seasons is, of course, of vast impor-

tance. As a striking instance, note the yield of grain to the acre in the United States, for three years: —

	CORN.	OATS.	WHEAT.
1889	27.0	27.4	12.9 bushels.
1890	20.7	19.8	11.1 "
1891	27.0	28.9	15.3 "

Can the general falling off in the yield of these three important cereals in 1890, and the great crop the following year, be attributed to anything less than the persistence of weather conditions in one direction or the other for long periods? Farmers watch the protracted spells of heat or cold, and the excess or deficiency of rainfall, with much more interest than they do the passing storm, unless it may be at harvest time.

Civilization insists upon modifying the winters in the middle and northern latitudes by the use of fuel, chiefly coal, the "portable climate" and extensive industries are engaged in effecting this result. It has been demonstrated that in the case of anthracite, a change of one degree in the average temperature for the six coldest months of the year, throughout the territory in which this coal is used, affects the consumption to the extent of two per cent. As there is an estimated range of 8° the difference between extremely warm and cold winters may be as much as sixteen per cent of the required production. The value of the coal, including transportation, is estimated at $200,000,000, so that it will be seen what an important factor temperature is in the two great industries of mining and transportation. This measure of anthracite also gives hints of the influence upon the vast quantities of bituminous coal, cord wood, oil, and gas used in heating dwellings, factories, churches, and schools, exerted by the varying temperature of our winters.

The snow blockades on the railroads, and interruptions of building operations, are incidents of cold, stormy winters, little experienced in open winters. Navigation closes or opens early or late as the temperature varies from the normal, and the great fisheries find luck or disaster according as the seasons are favorable or adverse. From the logger's camp in Michigan to the orange groves of Florida, all pursuits are affected. Thus in health, pleasure, and industry, the welfare of the people on land and sea is controlled by the general character of the seasons.

In the absence of thorough scientific treatment of the subject popular speculation is aroused whenever there is an unusually long period of warm or cold weather, or protracted rainy spell, or persistent drought, and discussion is indulged in as to sun-spots, the tilt of the moon's crescent, or periodicity as possible causes. If the abnormal conditions are repeated for two or three years in succession, conclusions are reached that our climate is changing, because of the fast extending application of electricity, the use of wire fences, the changing of the Gulf Stream, and other reasons.

My investigation leads me to conclude that the primal cause for the variations in the character of our seasons must be traced back through all the effects of diurnal and seasonal insolation, and of the cyclonic storms in the lower atmosphere, where it is manifested to us, up to the ever-flowing westerly current above.

The vast movement from west to east of the upper atmosphere in our middle latitudes, extending to a width of two thousand miles and more, I would liken to a river with its swift current in the middle, gradually lessening in velocity at the sides and bottom, though there is one movement different from any river, and that is the oscillations north and south with the sun. Like a river, however, it must have a persistence in its flow, because of the inertia of its great volume, and yet again, like a river, this inertia may be overcome, and the direction changed by obstacles or influences in its bed. A straight ditch through a meadow becomes a crooked creek, by reason of the inequalities the water meets in its flow, and the river in greater volume swings in longer stretches from bend to bend. This, then, is my thought, that the great atmospheric river changes its course, southing at one time and northing at another, because of the influences it meets in passing over the surface of the earth.

In the circuit of our hemisphere the current passes over two continents and two oceans, presenting wide differences, particularly of temperature, and many possibilities of disturbance. (1) Over the land in January the temperature is much below the record for same month over the sea, but by July the relations have changed and the temperatures over the ocean are much below the high record for the land; (2) There is a great difference in the range of the continental temperatures of the 50th

parallel as compared with the 30th parallel; (3) On the ocean the cold and warm halves of the year are about equally divided, while in some parts of the continent the warm half of the year is the shortest, and in other sections the cold half of the year is the shortest, in the one case the summer being the most intense and in the other the winter; (4) Over the ocean the normal or seasonal temperature crosses the mean of the year three or four weeks later than over the continent, and (5) the Gulf Stream and the Japan Stream bring tropical temperatures directly across the migrating westerly current. These are some of the rocks and sand bars in the bed of the great river, impressing themselves by convection upon the current above.

As these influences are constant in time and place it may be claimed that even if the great current should be disturbed by them, the effect would be the same in every season. This can be reconciled, for unlike a river, the banks of which yield but do not regain their position, the atmospheric current impinges upon banks which are always re-established by the forces which limit currents and calms, and therefore there are no fixed points in longitude at which the current takes a new course to the south, or yet again to the north, but in infinite variations new channels are taken.

A greater cause of disturbance than any of the five mentioned must be the tropical cyclones, and occurring as they do near the autumnal equinox with much greater energy in some years than in others, they are probably responsible for the extremely abnormal winter seasons. The tracks of these storms are directly across the current, and the whirling winds must be carried to a great height. When at the spring or neap tides there happen unusual floods or drought and the wind is at the same time against or with the ebb or flow, as the case may be, the result is abnormally high or low tides in our harbors. So may it not be that these tropical cyclones are to be found in conjunction with or opposition to the regularly occurring influences arising from the differences between the oceans and continents? If this hypothesis is correct, tropical storms in the Indian Ocean or Western Pacific may help to give character to the winter seasons of this continent.

Beside the slow and gradual northing or southing of the current we may well conclude that it is accelerated or retarded

in turn, and also that the strata of the atmosphere are raised or lowered by the various influences mentioned. Then concluding that the upper current, thus controlled, determines the tracks, the velocity and the intensity of the cyclones, we are back to earth again.

This great unnamed river of the atmosphere, so near to us and yet so far, has now in its bed, as it has had through the ages, the centres of civilization, and is destined to appeal to the imagination of men and to dare them, in its exploration, to supreme effort as have the unknown regions of *terra firma*.

Its direct flow from the original impulse given by the earth's rotation is masked by the cyclonic winds in the lower atmosphere, a composite of which is the prevailing westerly, but it may be that in the time coming when observations can be taken of wind velocity and direction at higher altitudes than now, the courses of the mid-channel will be charted, and forecasts made of our seasons.

CURRENT NOTES.

Recent Explorations of the Upper Air. — Mention has already been made in this JOURNAL (February, 1894, pages 423–427), of the successful experiment made by M. G. Hermite, of Paris, on March 21, 1892, with a small balloon carrying self-registering instruments, in obtaining records of pressure and temperature from the upper air. M. Hermite's balloon, *L'Aerophile*, reached a height of 52,500 feet, or about ten miles, which was by far the highest altitude ever reached by a balloon. The experiments with these balloons in France have given many valuable results, but the latter are all somewhat inaccurate, owing to the fact that the effect of the direct radiation from the sun, which increases greatly with increasing altitude, are disregarded. Dr. Assmann, of Berlin, has been experimenting for about two years past, in order to perfect some self-registering instruments which shall work accurately at great heights in the atmosphere. In the *Zeitschrift für Luftschifffahrt* for July, 1894, Dr. Assmann had an article on the voyages made by the balloon "Cirrus," with self-registering instruments.

The principal difficulties hitherto encountered in the working of the instruments have been met by the use of an aspiration attachment to the thermometer, whereby correct temperatures can be registered; by the use of photographic records, instead of curves traced in ink, which freezes at the low temperatures encountered in the upper air, and by the substitution of an ordinary alcohol thermometer for the Bourdon tube filled with alcohol, which is useless at temperatures below — 50° C. After many experiments, carried out by Fuess, a camera was constructed of aluminum, which photographed the fluctuations of the thermometer and the barometer on a Richard registering cylinder, covered with sensitive gelatine paper. The aspiration was accomplished by means of a simple mechanical apparatus.

The first attempt to send up the balloon "Cirrus," with the instruments, was made on May 11, 1894, in the presence of the German Emperor. The balloon is made of varnished silk; has a capacity of 250 cu. m. and weighs about 42 kgms., the registering apparatus weighing 2.6 kgms. The ascent of May 11 was unsuccessful, a height of 700 m. only being attained. On July 7, at 3.40 A. M., a second attempt was made, the balloon being filled with ordinary gas. Notices in German and Polish were attached to the basket containing the instruments, to the effect that a reward of fifty marks would be paid to the finder of the balloon, provided he did not open the registering apparatus. About 12 m. below the balloon, a small grappling anchor was attached at the end of a line, the object of which was to tear open the balloon as soon as the anchor struck the ground, and so to empty it without the assistance of anyone. On this ascent there was some interference of the rope holding the anchor and the bag containing the weight

used in driving the aspirator, the latter becoming wound around the rope. In future attempts this matter will be remedied. The balloon rose with great velocity, and turned W. N. W. and N. W. After seven minutes it changed its direction to S. W.; in five minutes more it turned further to the left, until at 4.05 P. M., it was moving from W. N. W. When last seen, at 4.25 P. M., it was moving S. E. The balloon descended to the surface in Bosnia, near the Servian frontier, about 3 P. M., travelling about 1000 kms. in ten hours, with a mean velocity of 28 metres a second. The following table gives the data obtained from the photographic records: —

Time.	Barometer. (In mm.)	Height. (In meters.)	Rate of Ascent.	Temperature C.	Temp. Decrease per 100 meters.
3.40	764	40	—	17	—
3.45	550	2,800	9.2 m. p. s.	7	0.37°
3.50	440	4,600	6.0 "	— 2	0.50°
3.55	340	6,600	6.7 "	—15	0.65°
4.0	250	9,000	8.0 "	—25	0.42°
4.5	200	10,600	5.3 "	—35	0.62°
4.10	160	12,150	5.2 "	—43	0.52°
4.15	125	13,800	5.5 "	—47	0.24°
4.20	110	14,650	2.8 "	—50	0.35°
4.25	95	15,600	3.2 "	—53	0.32°
4.30	85	16,325	2.4 "	—52	—0.14°

Above the height of about 13,000 meters above sea level, the ascent of the balloon was so slow, and the natural aspiration so much lessened in consequence, that the temperatures recorded are probably too high. The heights reached by the balloon at the different times are calculated on the basis of the actual temperatures recorded, and not on the basis of a uniform temperature of 0° throughout the atmosphere. The latter method of calculation gives too high values for the altitudes, in such cases as this, where the actual temperatures are very low. Unfortunately there was no provision made for the registration of a lower pressure than 85 mm., so that there is no record below that limit. Moreover, owing to the fact that the paper had space for six hours' registration only, no records were obtained during the last half of the voyage. The temperature curve shows a number of fluctuations, some of them reaching 10°, which occurred with a considerable degree of regularity every fifteen or twenty minutes. The cause of these fluctuations is not clear. They may have been due to the passage of cirrus stripes across the path of the sun's rays, or perhaps to the slow turning of the balloon itself, whereby the unaspirated thermometer would alternately be in the sunlight and in the shadow of the balloon.

The height reached by the "Cirrus" on July 7, 53,560 ft., is the greatest altitude to which anything made by man had up to that time penetrated.

Notes on the Hurricane of Sept. 25–27, 1894.— In the JOURNAL for March, 1894, page 475, there was printed an account of the weather phenomena observed at South Island, S. C., in connection with the hurricane of October 13 and 14, 1893. Gen. E. P. Alexander, formerly of the Corps

of Engineers, United States Army, who sent to this JOURNAL the curves for the 1893 hurricane, has also kindly sent a copy of the records he made during the September hurricane of the past year. The curves show the variations in pressure, temperature, wind velocity and direction, and state of tide from 12 A. M. Sept. 25, to 8 A. M. Sept. 28. The pressure began to fall rapidly about 8 A. M. Sept. 26, and reached its lowest point, 29.27 in., a little after midnight. It then rose to 29.52 in. at 10 A. M. Sept. 27, fell to 29.37 in. at 4 P. M., and then rose steadily. The temperature curve does not show any very decided fluctuations. There was a general fall during the early morning of Sept. 26, a rise during the period of lowest pressure, the maximum occurring between 8 P. M. of the 26th and 3 A. M. of the 27th; a fall coinciding with the rise in pressure to 29.52 in., and then a rise at the time of falling pressure to 29.37 in. On the 28th the rising pressure was accompanied by falling temperature. The wind was N. E. until 7 P. M. Sept. 26, with a fairly regular increase in velocity until that hour. At 7 P. M. Sept. 26, the velocity decreased rapidly from 75 ms. to 50 ms. an hour, and the direction changed from N. E. to E. This coincided with a marked depression in the pressure curve. At the time of the lowest pressure (12.30 A. M. Sept. 27), the wind velocity was 82 ms., the maximum, and the direction S. As the pressure rose the wind velocity decreased very rapidly, and the direction changed to S. W. at 10 A. M. Sept. 27, to W. at 3 P. M., and to N. W. at 8 P. M. The highest tide came at 8 P. M. Sept. 26, shortly after the preliminary barometric minimum, and five hours before the time of maximum wind velocity.

The weather changes were as follows: —

During the 24th the weather was thick and hazy, the wind S. and S. E., very light. The sunset was clear, but it was cloudy in the east. On the 25th the morning was cloudy, alternately lighter and darker, and growing uniformly dark and leaden in the afternoon. The 26th began with fine drizzling mist, coming in occasional squalls after midnight of Tuesday, and increasing to a good rain by 8 A. M. During the afternoon the wind and rain came in exceedingly violent puffs and squalls, moderating from 9 to 11 P. M., and then violent for a while. The decrease in violence at 9 P. M. coincided with a distinct rise in pressure at that hour. The lowest pressure, at about 12.30 A. M., Sept. 27, was followed at 2 A. M. by a breaking away of the clouds and the appearance of the stars. The wind changed to the W. in the afternoon, very light, and the weather continued cloudy. Fog and showers prevailed during the afternoon and evening.

Gen. Alexander sends the following notes in connection with his curves: "The barometer was an aneroid and its actual readings were all .22 lower than in the diagram, that being the average correction for it, gotten by comparing daily readings with Weather Bureau daily weather maps. Wind is estimated velocity of strongest puffs from time to time. This storm acted strangely, in that the centre seemed to start away and come back a couple of times, and it was two days before the barometer got back to the normal, the weather being all the while foggy and like the weather in the eye of a cyclone, the wind, too, dying out from the south, and never more than a gentle breeze from the west."

Annual Report of the Work of the Prussian Meteorological Institute. — The annual report of the Director of the Meteorological Institute of Prussia is at hand. The year 1893 witnessed the beginning of regular observations at the observatory at Potsdam; the successful accomplishment of several scientific balloon ascents; the participation of the Institute in the World's Fair at Chicago, and the general introduction of standard time. The introduction of standard time brought up the question as to whether the local observations should be continued at the same local hours as before, or whether they should be made according to the new time, which would to a considerable extent interfere with a comparison of the observations. As a result of careful deliberation it was decided to have the observations at the stations of the higher classes made according to local time, as heretofore, but the standard time was introduced for the precipitation and thunderstorm records. The Institute has, therefore, to deal with two different kinds of time: one, the local, in the climatological division; the other, the standard, in the thunderstorm and precipitation division.

The total number of stations of the four classes was 186 at the end of the year 1893; and the number of precipitation stations, 1,773. Further energetic attempts have been made to build an observatory on the Brocken, but the plan has not yet been carried out. As stated in the report for 1892, it has for some time been the custom of the Institute to send out 200 copies of the meteorological journal, "*Das Wetter*," to its observers, as a slight return for their gratuitous services. During the past year it has been found possible to increase the number of copies thus sent out, and it has been found that this monthly publication serves to incite and to encourage the observers in their faithful though often monotonous work. Thunderstorm observations have been carried on as in previous years, the number of observers being 1,407. The Potsdam Observatory has, since January, 1893, given records (eye readings) of the different meteorological elements at 7 A. M., 2 and 9 P. M., as well as automatic records.

The scientific balloon voyages of the year, which were carried out with the co-operation and assistance of the Meteorological Institute, were very successful. The Emperor, the Royal Academy of Sciences, and the German Verein zur Förderung der Luftschifffahrt, were also interested in the undertaking. A number of ascents were made in 1891 and 1892, and in 1893 fifteen separate ascents were carried out. Lieut. Gross was in charge in all these fifteen voyages, and Prof. Dr. Assmann, Dr. Kremser, and Herr Berson, of the Institute, took part in some of them, Herr Berson going up in every case but the first ascent. The valuable results of these trips will be published in detail by the Institute, as soon as the ascents are concluded.

Annual Report of the New York Weather Service. — The fourth annual report of the Commissioners of the New York State Meteorological Bureau and Weather Service has recently been issued. During the year the number of display stations increased from 55 to 197, including 170 stations displaying both temperature and weather indications, and 27 displaying cold wave warnings only; 124 stations are now in operation. A crop bulletin

was issued each week from April 9 to Oct. 11, 78 crop correspondents sending in weekly reports, and monthly bulletins were issued each month. During the year 30 stations were inspected. Efforts have been made to secure competent observers in the central part of the Adirondack region, with the result that three such have been found, in very favorable locations. A considerable increase in the number of rainfall observers will be made a special feature of the work hereafter. Anemometers at 10 stations, and thermographs at 11 stations have been examined, repaired, and adjusted.

The report contains the observations for each month at all the stations; daily and monthly mean temperatures and precipitation; temperature and rainfall statistics for the State, and charts showing the monthly and yearly precipitation and distribution of temperature. The excellent charts which the New York Weather Service has issued furnish admirable material for an investigation into the effects of the Lakes on the temperature and precipitation of the State, and it is to be hoped that an exhaustive treatment of this subject will soon be forthcoming.

The report is signed by J. F. Crooker, Superintendent of Public Instruction; C. L. Crandall, Acting Professor of Engineering at Cornell University; and Simeon Smith, Commissioner, the two first-named gentlemen being Commissioners *ex officio*.

Tornadoes in Iowa in September. — In the September number of the "Monthly Review of the Iowa Weather and Crop Service" there is an account of the destruction caused by tornadoes in Iowa on Sept. 21. The main disturbance was a group of thunder and hail storms, accompanied by heavy wind squalls, and two or three small but vigorous tornadoes. The distance traversed, on a nearly direct E. by N. course, was over 200 miles, and the storm-belt was of a fan-shaped form, varying from a few thousand feet at its beginning to about 25 miles in width at its eastern extremity. Fortunately no large towns lay in the pathway of the storm, but 53 persons were killed by it, and many others were seriously wounded. At Emmetsburg the observer claims to have distinctly seen three separate tornado funnels, and it appears that these moved on nearly parallel lines for some distance, and then diverged as they moved eastward. From the Algona *Upper Des Moines* the following extracts are taken: "The wind performed many curious freaks along its course. . . . An iron pump and the iron tubing were taken out of the well, and a granary full of wheat was left untouched. . . . At Mr. Rice's an empty wash tub stood on his water tank in front of the wind-mill. The mill and tower and chicken house were torn out completely, but the tub never moved an inch. The chicken house, a heavy 16 x 16 foot building, was taken around the end of the hay stack, and set in between two red oak trees, where it would have been difficult to pull it with horses, without a window-glass being broken." The observer at Osage reports: "The trees and corn on the north side of the track were bent or broken towards the south or southeast, and on the south side towards north or northeast. At some points it showed that trees were broken towards the west or northwest as the tornado was approaching, and afterwards other trees and *débris* were thrown upon them from the opposite

direction, as the storm passed ahead. This was nicely shown in one grove where a part of the trees fell to the west at the beginning, and over them are laid another lot of trees which fell towards the east and southeast."

The Roumanian Weather Service in 1893.—The Seventh Annual Report of the Meteorological Institute of Roumania, by the Director, Stefan C. Hepites, shows an encouraging condition of meteorological work in that country. The year 1893 was marked by the appropriation of a sum of money for the establishment of meteorological stations in different parts of the country, and by the building of a new central station which will be completed in 1894. The rapid accumulation of meteorological data has made a study of the climatology of Roumania possible, and some papers on climate have already been published.

During the past year a number of new instruments were purchased for the central station, as well as for the creation of auxiliary observing stations in different parts of the country. The number of stations has been considerably increased since last year. Most of the observers are willing to keep the records without any compensation, but it is found necessary, in some cases, to make a slight financial return in order to ensure the continuance of the records. In May the telephonic connection of the Meteorological Institute with the general direction of telegraphs made it possible to send daily messages as to the weather to Vienna, St. Petersburg, Sofia, and Athens. Messages were also received from Sofia and Athens, and from some of the second order stations in Roumania. Seventy new rain-gauge stations have been established, and at the end of the year 1893 159 stations in all were in operation, viz.: 1 first order; 23 second order; 2 third order and 133 fourth order.

Several publications have been issued during the year 1893, including volumes VI. and VII. of the *Annales de l'Institut meteorologique de Roumanie*, and the *Bulletin des Observations meteorologiques en Roumanie.*

Tornado Studies. — M. E. Durand-Gréville, of Bois-Briou, Ste. Gemmes près Angers, France, wishes the following information regarding tornadoes in the United States: —

The meteorological conditions of a day, as recent as possible, on which the tornadoes had an unusual violence and a movement of translation much greater than the average.

The names and addresses of all the directors of public and private observatories lying within a radius of about two hundred miles of the places visited by the tornadoes of this day, in order to obtain copies of the traces of the self-recording barometers, anemometers, etc.

Boletim da Commissão Geographica e Geologica do Estado de S. Paulo.— The publication of climatological data for this Brazilian Province (since a State) for the years 1887–8, as mentioned on page 211 of this JOURNAL, has been followed by two more volumes bearing the above title, containing observations for the years 1889 and 1890, made, centralized, and discussed

under the direction of Alberto Loefgren. No. 8 of the *Boletim* gives complete summaries for 1890 at eight second-order stations, and more or less complete monthly summaries at five other stations. Numerous diagrams aid a discussion of the annual and diurnal march of the various elements at the capital of S. Paulo and at the other stations.

Mr. Loefgren announced in 1891 that a grant of money obtained from the State permitted the extension of the climatological service to include 37 stations, of which 10 were to be of the first order with self-recording instruments, 17 of the second order, and 10 of the third order with thermometers and rain-gauges. No information has been received as to whether this scheme has been carried out. A. L. R.

Storm Tracks off the Eastern Coast of the United States. — A Supplement to the August *Pilot Chart of the North Atlantic Ocean* contains a series of six small charts, showing the storm tracks traversing the United States, and those coming from the West Indies, during the months of August, September, and October, 1888–1893, inclusive. These charts show that the storms which travel eastward across the continent into the ocean are more frequent than the West Indian hurricanes during these months, and require just as much vigilance on the part of seamen in the manœuvring of their vessels as the much talked of West Indian hurricanes. A study of the charts shows that during August and September the land storms usually enter the Atlantic across Newfoundland and Labrador, while in October they enter the ocean all along the coast between Cape Hatteras and Newfoundland. The tracks of the West Indian storms are by no means all regular, but are sometimes deflected abruptly or prevented from curving until the higher latitudes are reached.

CORRESPONDENCE.

NEWSPAPERS AND THE WEATHER BUREAU.

Editor of the American Meteorological Journal:

The relation of science and scientific men to the daily newspaper is rather an anomalous one. The newspaper of to-day affords a medium of unusual value for setting up sound thinking among the greatest number of people, and yet nothing is more irregular than the method of the average newspaper. It vacillates between two extremes; on the one hand the reader is deluged with the uncouth terminology of medicine, the formulæ of astronomy, or a brochure on esoteric psychics, and then for a period all science is in taboo, and such a session of scientists as the annual meeting of the American Association for the Advancement of Science is treated as a joke. It is this unreliability, this unsteadiness, that is so serious a problem. Probably of all the sciences the subject of the weather suffers the most. Simple weather facts refracted through the dense medium of the reporter result in wonderful distortion. The scientific expert is rated low and the newspaper is apt to pay more attention to some quack weather prophet than to the local observer. That any newspaper, at this period of scientific progress, should pay any attention to these quacks is discreditable. Meteorology is too near to us all to let this condition of things remain. The change must come, and as the initiative is not likely to come from the newspaper or newspaper man, we must look to the Bureau for the inauguration of what might be called an era of illumination.

With regard to the Weather Bureau much can be done along normal lines to improve the situation. The question is hardly one of space, and without asking for any additional space, there is a way in which the Bureau can be of service to the newspapers, and both directly and indirectly impress itself on all the matter written on weather topics. As a basis for this improved relation, as a very *sine qua non*, the Bureau should issue a general weather chart (about the size of the Hydrographic Bureau's monthly charts), which could be hung up in every newspaper office throughout the land. This chart should contain a large generalized weather map of the United States; not so large, however, but that enough space be left for letter-press embodying in as simple language as possible the most accurate information on weather-lore as it is held to-day. Particular pains should be taken to define the ordinary meteorological terminology. Tornado, thunder-storm, hurricane, cyclone, should be carefully differentiated and explained with reference to the map, which should contain some such general and typical storm on it as the cyclone which conditioned the tornadoes at Louisville, on March 27, 1890. On the map also could be shown a typical hurricane

from the West Indies, with paths of others that have been charted. In the letter-press several storms could be analyzed, and salient facts as to storm formation and movement presented in a lucid manner; for the most important condition of all is, that it should be written from the point of view of the non-learned reader. Such a chart, with all technical subtleties suppressed, and arranged so that those who never before knew what a storm was should understand for once, would work a revolution in the average newspaper office. Instead of the blundering use of meteorological nomenclature now the rule, an exact use would set in, and with the chart ever near at hand for instant reference with which to compare some telegraphic despatch, the general and local weather article would constantly improve. This is a first step. It would be a sort of Piddington's newspaper horn-book.

Following close upon the chart, to the issue of which attention could be called from Washington explaining just what the Bureau hoped to accomplish by it, there should be sent out a small pamphlet calling the attention of the newspaper to the importance of printing all the data sent out daily from Washington in connection with the nightly forecasts. Many papers print the forecasts only, but they should be urged to use also the paragraph which gives the general forecast of weather conditions the country over, which, as it locates the "lows" and "highs," is invaluable for reference afterwards. In addition, the newspapers should be asked to print the monthly summaries, most valuable also for reference, and the statement of monthly averages (Form 1079, Met'l.), which is a sort of "monthly forecast." Few newspapers print all these data now, and if the more important papers, the country over, were gotten into this procedure, as a matter of course it would be no mean reform. This is the second step in the improvement of the relations of the Bureau with newspapers; and the third step is the question of the reproduction of the weather map daily. Long before this step is taken it is to be hoped that the weather map will come into a more general use among laymen and newspaper men for reference and study, so that it will be intelligible to those who see it printed as well as to those who print it.

So far as most maps now used in newspapers go they are glaring failures. The chalk-plate process prints a map that simply uses up space, and is worthless. It is illegible and meaningless, even if one takes for granted it is understood by the public. The letter-press that accompanies it is too stilted and general in character. There are no mechanical difficulties in the way of reproducing a good two-column map in our great papers, but the trouble comes in getting a good map to reproduce. What is wanted is a distinct, legible map, with the "highs" and "lows" accentuated, and only the important stations shown. This is a basic condition, but above that in importance is the explanation, not wooden, which should accompany the map from day to day as it varies, and explain just what it means. There are some who declare, I believe, that no explanation is needed. That is pure fatuity. There never was a greater mistake. Looking at this matter from the inside of a newspaper office, the need of the simplest, primer-like explanation becomes absolutely imperative. Without it the map is worth-

less. A great deal can be said in from one hundred to three hundred words in small type, under a two-column cut and yet not eat into space. But of course all this pre-supposes a closer relation of the local forecast officials and the newspapers; for some one must prepare the map and letter-press to accompany it, and it cannot be done in a perfunctory way, or failure will be the result. This, then, is the third step in the better relations which should exist between the Weather Bureau and the newspapers. Many would make it the first, but one must crawl before one can run. What all newspaperdom needs is a general illumination in weather lore. The local officials do much. Their words often fall on stony ears, and yet in spite of, not by means of, the reporters, they get sound weather facts before the people. If all would work together in the way here suggested, a great change would occur in a few years, and the weather articles would no longer be a reproach to the intelligence of the newspapers, and a confusion to the readers.

H. M. WATTS.

PHILADELPHIA, PA., November, 1894.

THE BLACKBERRY WINTER.

Editor of the American Meteorological Journal:

According to a recent promise made in a letter dated June 11, I have, since my return to Helena, made diligent inquiry regarding our "Blackberry Winter," and find the term is not so generally used as I had supposed. That must be accounted for by the general indifference to observations of any kind, but it puzzled me greatly at first.

However, the name is frequently given in Kentucky, as well as here, to a cold spell that is almost sure to come some time in the month of May, usually when the blackberry blooms. If it does come then, there will be an abundant crop of berries; if not, the bushes will yield none at all or only a very small crop.

Curiously, after hearing the above, I decided to look up the temperature record for 1893–1894, as I had data regarding the blackberry crop for both seasons, and the result is here given. In 1893 the temperature fell below 54° but once during the whole month of May (that was May 4), while for twenty-six days it ranged from 54° to 72° as its minimum mark. The blackberry crop was short. In May, 1894, the minimum thermometer kept steadily marking some one of the sixties until the 19th, 20th, and 21st, when it changed to 45°, 44°, 46°, and it marked sixty but once after that during the remainder of the month. The blackberry crop was immense.

M. L. STEPHENSON.

HELENA, ARK., Sept. 29, 1894.

WEATHER MAPS AND FORECASTS IN SWEDEN.*

PROF. W. M. DAVIS,
Harvard College, Cambridge, Mass., U. S. A.:

Dear Sir, — In your "Elementary Meteorology," page 328, the following erroneous statement is made: "The following countries maintain a system of observations, and issue certain reports, but do not prepare daily maps or issue forecasts, — Norway, Sweden, Denmark," etc.

Now, both Sweden, Norway, and Denmark since many years do prepare daily weather maps and issue forecasts. As to our office here in Stockholm daily weather maps (for 8 A. M.) have been prepared from its beginning in 1873, and forecasts for the next 24 hours have been issued once a day (about 1 P. M.) since the 15th July, 1880; also, since the summer of 1890 we have prepared weather maps twice a day (for 8 A. M. and 9 P. M.), and issued a daily forecast as before during the whole year; and, moreover, during the months of July and September prepared daily weather maps for 4 P. M., and issued daily forecasts (about 6 P. M.) for the following day for agricultural service. Also, a part of these maps has been published, — 1874, July 1 — 1877, Dec. 31, a "Väderleks-bulletin" was published lithographically, but afterwards, in order to have it more widely spread, it was published in the newspapers. At present, nine daily newspapers in Stockholm receive, and publish, more or less completely, our weather reports and forecasts, five of them giving daily weather maps. These newspapers are sent all over this land. Moreover, most of the daily newspapers of other cities in Sweden publish our forecasts that they obtain by telegraph or telephone. Also, our reports are sent telegraphically to several other subscribers, and along the railroads. The summer forecasts especially are spread all around the country by telegraph, telephone, and signals.

I hope you will correct the error as soon as possible. If you cannot give the correction in the book itself, I beg you to publish the facts above mentioned in the AMERICAN METEOROLOGICAL JOURNAL as a correction.

Yours sincerely,

R. RUBENSON.

METEOROLOGISKA CENTRAL ANSTALTEN, STOCKHOLM, June 6, 1894.

OBSERVATIONS ON CUMULUS CLOUDS AT WINTHROP, MASS.

Editor of the American Meteorological Journal:

An interesting phenomenon was recently observed at Winthrop, Mass., in connection with the formation of cumulus clouds. On Saturday, Sept. 29, in the early morning, a dense fog covered this section, clearing away at 8 A. M., with a light east wind. The east wind prevented the smoke

* The accompanying communication has been handed to the Editor for publication by Prof. W. M. Davis.

from the many fires in Boston and vicinity from advancing towards the east, and thus caused a dense mass of smoke on the northwestern and western horizon. At 11.25 A. M. a small fracto-cumulus was seen forming at the top of a thin column of smoke of the same diameter as the cloud, which extended from the top of the mass of smoke to the base of the cloud. At all other points the summit of the mass of smoke was level. The fracto-cumulus did not attain any great size, but quickly became ragged and disappeared, the column of smoke also disappearing at the same time.

This was the only cloud seen forming over the smoke, and I accounted for the trail of smoke as being caused by ascensional currents rising to the cloud and, in passing through the mass of smoke, taking some of the particles of smoke along with them.

A. E. SWEETLAND.

WINTHROP, MASS., Oct. 6, 1894.

BIBLIOGRAPHICAL NOTES.

DESTRUCTIVE EFFECTS OF WINDS ON SANDY SOILS.

F. H. KING. *Destructive Effects of Winds on Sandy Soils and Light Sandy Loams, with Methods of Protection.* University of Wisconsin, Agricultural Experiment Station. Bulletin No. 42. 8vo. Madison, 1894. Pages 29, Figs. 16.

Prof. F. H. King, of the Agricultural Experiment Station of the University of Wisconsin, gives us in this Bulletin the results of a study he has recently made on the effects of winds on sandy soils and loams, and on the methods which may be used to prevent the destruction thus caused. The district in which the author conducted his studies is a rudely crescent-shaped tract of land a little to the south of the centre of the State, covered over most of its area with a light, sandy soil or sandy loam. During the prevalence of strong winds the drifting over the fields is very bad, the crops being cut off or broken by the sand in such a way that they lie flat on the ground, or the loose soil which covers recently planted oats being blown away, leaving the kernels of grain entirely exposed. A study of the district in question showed, among other facts, the protecting influence of board fences, fields of clover, trees, etc., on fields of oats, and other crops to leeward of them, this protection extending in many cases two hundred feet out into the planted fields.

In order to determine the influence of woods, grass fields, and hedge-rows on the rate of evaporation and amount of moisture in the air over fields to leeward of them, Prof. King made a number of observations with the Piche evaporimeter, modified so as to have the evaporating surface much larger than usual. The data thus obtained give 24 per cent greater evaporation at three stations between 280 and 320 feet from the woods than at three stations between 20 and 60 feet from the woods. Another set of observa-

tions shows that there is an increasing amount of evaporation until 300 feet from the woods is reached, while beyond that the evaporation is practically the same. At 300 feet the evaporation is 17.7 per cent greater than at 200 feet, and 66.6 per cent greater than at 20 feet from the woods. Even a very scanty hedge-row is found to exert a decided influence upon the rate of evaporation to leeward of it. A field of clover shows a similar influence, the evaporation at 300 feet away being 39.78 per cent greater than at 20 feet away, and 7.44 per cent greater than at 150 feet away.

Further observations were made on the amount of moisture in the air at different distances to leeward of woods, hedge-rows, and clover fields, with the result that the relative humidity of the air in the latter cases is found to be greater within about 300 feet of the protecting area than over the unprotected fields at a greater distance.

As a direct result of his investigation, Prof. King comes to certain conclusions as to the means of preventing the destructive effects of winds on crops. The first conclusion is that if light soils are cultivated in long narrow lands, not wider than fifteen to twenty rods, alternating with similar strips of grass, which, if possible, should be largely clover, the crops would be well protected by the influence of the grass, which would extend across the cultivated strips. Secondly, the effect of large fields of naked sandy soil in hot weather is to expand the air in contact with them, the expanded air rising and a cold current from above coming down to take its place, striking obliquely upon the surface, raising a cloud of fine dust, and rolling the coarser grains along the surface. Moreover, the descending air has a peculiar parching effect, as it is naturally dryer than the ground air. It would seem, therefore, that these local currents in Wisconsin are similar in this respect to the hot winds of Texas, recently carefully studied by Dr. I. M. Cline. The cultivation of these large fields in alternate narrow strips of crops and grass would undoubtedly prevent this destructive action to a large extent, the tendency of the grass strips being to lessen the heating of the overlying air, to lessen the turbulent character of the surface wind, and to increase the moisture of the air and lower its temperature. Other methods of prevention are: increasing the water-holding power of the soil, by planting clover, by manuring, and by rotating the crops; leaving the ground uneven after seeding, instead of smooth, the unevenness tending to retard the velocity of the wind; clearing the wooded lands in north and south belts, in order to leave wind-breaks in the path of the prevailing winds, and the planting of wind-breaks, which, as has been seen, act very beneficially on crops to leeward of them.

Prof. King's report is one of value and interest to the meteorologist as well as the agriculturist. While the primary object is to benefit agriculture in Wisconsin, the author's investigations on the effect of clover fields, woods, and hedge-rows on the humidity and evaporation of the air to leeward of them, are of distinct value in the present much-vexed question of the effects of forests on rainfall and climate. Prof. King's work on this subject, as well as his previous investigations in regard to the fluctuations and rate of movement of underground water, are indications of the valuable results now

being obtained in agricultural meteorology in this country. The field of work now opening up for investigators along such lines as Prof. King has followed is a most attractive one, and the next few years will undoubtedly bring much of value to meteorology as well as to agriculture, from our agricultural experiment stations.

DISTRIBUTION OF THUNDERSTORMS OVER THE EARTH'S SURFACE.

A. KLOSSOVSKY. *Distribution Annuelle des Orages à la Surface du Globe Terrestre.* 4to. Odessa, 1894. Pages 4. 1 Ch.

An interesting and valuable contribution to the literature in connection with thunderstorms has recently come to hand in the shape of a chart of the annual distribution of thunderstorms over the surface of the earth. This chart is the work of Dr. A. Klossovsky, Professor in the University of Odessa, who has already given much time to the study of these phenomena, and has published several papers on this subject. In the *Revue Météorologique, Travaux du Réseau Météorologique du sud-ouest de la Russie*, 1892, Vol. III., Odessa, 1893, pages 37–67, there were printed tables showing the annual distribution of thunderstorms at 430 stations over the earth's surface. These tables were based on the tables by Klein in *Petermann's Mittheilungen*, 1870, page 427, and on those by Fritz in the same Journal, 1871, page 114, together with additions and changes made by Habbe, of the Odessa Observatory. These tables give the name of the station, its latitude and longitude, height in meters; years during which the observations were taken; the average number of thunderstorms by months and by the year; the amount of precipitation, and the sources from which the data were derived.

On the basis of these tables Prof. Klossovsky has constructed his chart of thunderstorm distribution. The chart is colored in different shades of green and red, to show the average number of storms per year, the darkest green denoting the largest number, and the lightest red the smallest number of storms. As Dr. Klossovsky says, this chart could have been roughly drawn on the basis of the already existing charts of rainfall and temperature, for, as is well known, precipitation, temperature, and thunderstorms are very closely connected. A comparison of the thunderstorm chart with a mean annual rainfall chart is interesting, and shows, as was to have been expected, a striking resemblance between the two. The regions of greatest rainfall, along the equator, are also found to be regions having the largest number of thunderstorms, the largest number (50–100 and more annually) being found over Central America and northwestern South America, the coast of the Gulf of Guinea, the southeastern corner of Asia, and the islands north of Australia. These are all regions of very heavy rainfall. Between 30 and 50 thunderstorms a year occur along the northeastern and eastern coasts of South America, and the southeastern part of North America, across central and southern central Africa; small districts at the head and on the eastern shore of the Adriatic, the western coast of Italy, and the western coast of

France on the Bay of Biscay, along the base of the Himalayas in northeastern India and northern Burma, and on the eastern coast of Australia. From 15 to 30 storms a year occur in central South America, over a belt extending from southwest to northeast, across the central United States; over the greater part of Europe; north and south of the belt of heavy rainfall in central Africa; over India and southern and eastern China, and in the southeastern and western parts of Australia. The districts having less than 15 thunderstorms show a close similarity to the regions having correspondingly smaller amounts of rainfall.

Prof. Klossovsky's chart is, of course, only a preliminary one, and will be subject to correction as more and more reliable data are accessible. A difficulty regarding the accuracy of the *numbers* of thunderstorms on which the chart is based comes from the fact that there is no definite conclusion among meteorological observers as to what constitutes a thunderstorm. While many consider that lightning alone should be recorded as a thunderstorm, others believe that the lightning should be accompanied by thunder and rain, etc. This discrepancy, of course, does not interfere with the general accuracy of the chart which, as stated above, could have been drawn tolerably well without any direct thunderstorm data.

Dr. Klossovsky's work on thunderstorms, which has already given us many valuable results, has now provided students of meteorology with a chart which will be of general interest and value.

EFFECTS OF WEATHER CHANGES IN CAUSING DISEASE.

I. M. CLINE. *The Climate of Texas in its Relations to the Distribution of Diseases, and the Effects of Climate and Weather Changes in causing Diseases and Deaths.* Texas Weather Service, Special Bulletin No. 4. 8vo. Galveston, 1894. Pages 32. Pl. ix.

The Texas Weather Service, in co-operation with the Galveston Cotton Exchange, has lately been issuing a series of special bulletins on matters connected with the climate and crops of the State, which promise to form a valuable contribution to the literature of these subjects. Although thus far chiefly of local interest and value, these bulletins have, nevertheless, contained much that is useful to students of climatology outside of Texas.

The latest issue in this series is Special Bulletin No. 4, by Dr. I. M. Cline, Director of the State Weather Service, the title of which shows clearly the nature of the subject dealt with. Dr. Cline has already written on the medical climatology of his State, and from his long experience as physician as well as meteorologist, he is eminently well qualified to speak on the relation of climate and weather changes to disease. In the present bulletin he discusses the Topographic and Physical Features of Texas; its Climatic Conditions; the Effects produced by certain Climatic Conditions on the Human Organism; and the Distribution of Diseases and the Manner in which they are influenced by Climatic Conditions. The bulletin will repay careful reading on the part of those interested in medical climatology,

as well as of those who take nothing more than a general interest in meteorological matters.

Dr. Cline has drawn a series of curves illustrating the relation between the annual temperature curve and the deaths from various diseases. In the case of consumption and pneumonia the maximum of the temperature curve coincides nearly with the minimum number of deaths from these two diseases. The deaths from malarial diseases show their maximum and minimum a little later than the maximum and minimum of the temperature curve.

We congratulate the Texas Weather Service on the energy and activity of its Director.

FIRST ANNUAL REPORT OF THE NORTH DAKOTA WEATHER SERVICE.

B. H. BRONSON. *First Annual Report of the North Dakota Weather Service for* 1893. 8vo. Grand Forks, N. D., 1894. Pages 70.

We are glad to note the appearance of the First Annual Report of the North Dakota Weather Service, recently issued by Mr. B. H. Bronson, the Director of the Service. As this is the initial number, a short account of the establishment of the State Weather Service work in North Dakota is in place here.

The North Dakota Weather Service was organized in July, 1891, having been, prior to that time, under the supervision of the Director of the South Dakota Weather Service. From July, 1891, to March, 1893, all the supplies and instruments, etc., were furnished by the National Weather Bureau, but on March 13, 1893, the Governor approved an appropriation made by the Legislature for the support of the Service. At the end of the year 1893 37 stations, from which monthly reports were received, were in operation, and forecasts and warnings were being telegraphed to 31 display stations. About 300 copies of the monthly bulletin have been issued every month, and about 350 copies of the crop bulletin were sent out each week during the growing season.

The mean annual temperature of the year 1893 was 36°, which was 3° lower than the normal obtained from observations of many years, taken at military posts and Weather Bureau stations. The normal temperatures taken by seasons are as follows: Jan.—March, 11°; April — June, 54°; July — Sept., 65°; Oct. — Dec., 27°. The precipitation for the year was 15.85 in., the normal being 17.23 in. The monthly mean maximum temperature during the year was 48°; the monthly mean minimum, 23°. The highest temperature reported was 112°, from Medora, Billings County, in July. The lowest was —54°, from Willow City, Bottineau County, in February.

Mr. Bronson's report does him great credit, and promises well for the work of his service in the future. The rapid development of our State Weather Services during the last few years has been one of the most encouraging features in the history of meteorological observation in the United States, and the North Dakota report shows that the newer State Weather Services are doing their share of the work well.

TITLES OF RECENT PUBLICATIONS

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU, WASHINGTON, D. C.

(An asterisk [*] indicates that the publications thus designated have been received by the Editor of this JOURNAL.)

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